Development of Multi-chroic Millimeter-wave Polarization Sensitive Detector Arrays

Completed Technology Project (2012 - 2016)

Project Introduction

Improved measurements of the polarization of the Cosmic Microwave Background (CMB) will improve our understanding of both cosmology and fundamental physics. Measurements of CMB lensing will provide tight constraints on the sum of the neutrino masses and dark energy. Observations of large angular scale polarization provide a unique opportunity to probe inflationary physics at the GUT energy scale through searches for the imprint of inflationary gravitational waves. Both of these measurements are limited by detector technology and would benefit from multi-frequency observations to remove foregrounds. This fellowship will support my efforts to develop multi-chroic polarization-sensitive detectors with the McMahon group at the University of Michigan. These new pixels will image the polarization of the CMB in multiple frequency bands simultaneously. This can be used to improve the sensitivity, spectral resolution, and spectral reach beyond what is achieved with the current generation of single frequency detectors. Therefore, multi-chroic detectors represent one of the most promising approaches for improving the cosmology possible with future experiments. This technology will be especially valuable for space missions where the cost of increased focal plane area is extremely high. The initial goal for this work is to develop a 90/150 GHz array and deploy it as part of the ACTPol project. This multi-chroic array will image the polarization in the 90 GHz and 150 GHz bands, which offer the best signal to foreground ratio on the CMB and therefore the best raw sensitivity to lensing and inflationary B-modes. The improved sensitivity and frequency coverage will enhance measurements of lensing and polarization. We expect this will be the first use of multi-chroic detectors on a CMB experiment. Results from this field test will be used to further improve these detectors and will raise the technical readiness of these detectors to TRL 5. This work will yield both a short-term scientific results as well as a longer-term impact from the application of this technology to future experiments operating over a wide range of frequencies. During the second half of this fellowship I will incorporate the lessons learned in the field into improved detector designs and I will investigate scaling these detectors to the new frequency bands needed to characterize and remove CMB foregrounds. These detectors would enable a range of new polarization experiments. This work will involve significant collaboration with Dr. Kent Irwin at NIST Boulder and Dr. Edward Wollack at NASAs Goddard Space Flight Center. Working with these groups, I will work on RF design, optical testing, and array design with a goal of producing sensitive multi-chroic detectors suitable for a wide variety of future experiments. This work addresses both technology development for the Physics of the Cosmos Program (PCOS) and technology development for the Cosmic Origins Program (COP) science areas by improving the sensitivity of millimeter-wavelength detectors and working towards improved dark energy detection capabilities. This work also applies directly to Technology Area 8 (TA08): Science Instruments, Observatories and Sensor Systems through its advancement of microwave detector technology and potential to increase future focal plane density.

Project Image Development of Multi-chroic Millimeter-wave Polarization Sensitive Detector Arrays

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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Responsible Program:

Space Technology Research Grants

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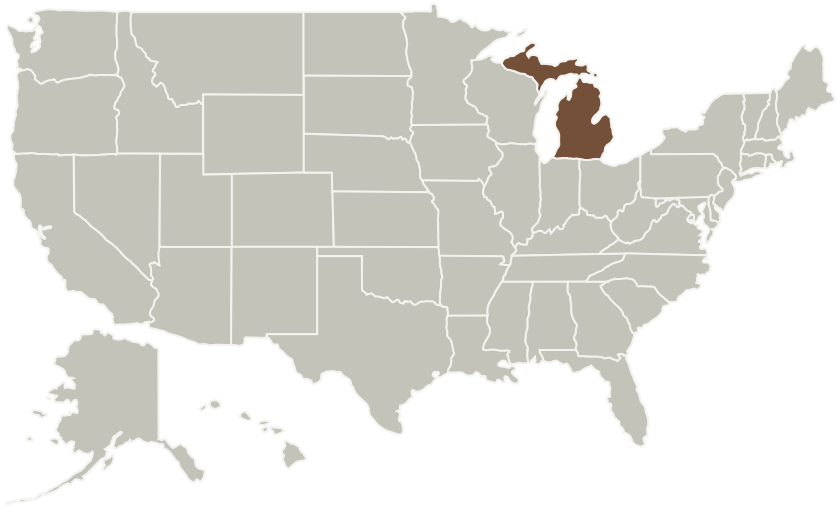
Anticipated Benefits

This work addresses both technology development for the Physics of the Cosmos Program (PCOS) and technology development for the Cosmic Origins Program (COP) science areas by improving the sensitivity of millimeter-wavelength detectors and working towards improved dark energy detection capabilities. This work also applies directly to Technology Area 8 (TA08): Science Instruments, Observatories and Sensor Systems through its advancement of microwave detector technology and potential to increase future focal plane density.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of Michigan-Ann Arbor	Supporting Organization	Academia	Ann Arbor, Michigan

Primary U.S. Work Locations
Michigan

Project Management

Program Director:
Claudia M Meyer

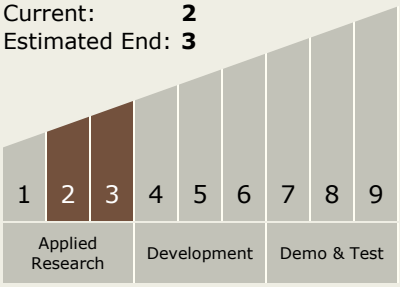
Program Manager:
Hung D Nguyen

Principal Investigator:
Jeff Mcmahon

Co-Investigator:
Charles D Munson

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes

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Images

11528-1363179242978.jpg
Project Image Development of Multi-chroic Millimeter-wave Polarization Sensitive Detector Arrays
(https://techport.nasa.gov/image/1754)

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html